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(54) THERMAL EXPANSION COMPENSATING DEVICE

(71) We, ERŐMŰ- ES HÁLÓZATTERVEZŐ VÁLLALAT of 3 Szechenyirakpart, 1054 Budapest, Hungary, a body corporate organized under the laws of Hungary, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention concerns a heat expansion compensator provided with a resilient linkage which serves for accommodating the displacements of pipeline systems and vessels due to temperature changes.

Conveying water, steam, gas and other fluids in pipelines is now widely practised but a serious problem is caused by the heat expansion of the pipelines, (primarily consisting of steel pipes) irrespective of the cross-sectional shape thereof. The equation for the one-dimensional heat-dilation or thermal expansion is given by:

$$\Delta l = \alpha . \Delta t . l_0$$

where: Δl is the change in the length in millimetres, α is the coefficient of linear thermal expansion in $(°C)^{-1}$ Δt is the change in temperature and l_0 is the original length in millimetres.

From this equation it can be seen that apart from the coefficient of thermal expansion which characterises the material the numerical value of the change in length is determined by the temperature difference and the longitudinal dimensions. In the case of pipelines, the longitudinal dimensions are always significant and in the decisive majority of cases the temperature differences cannot be neglected either.

For these reasons, in technical practice so-called tube compensators have become generally used for compensating the thermal expansion.

The dimensions and output of industrial plants has recently increased very considerably and consequently the pipelines serving them have also increased in their dimensions and operational parameters such as pressure or temperature. These large dimensions, such as the diameter and wall-thickness, combined with temperature oscillations due to the environment and the technology itself as well as the increasing pressures cause an ever more serious rigidity problem in pipelines due to thermal expansion.

The increase in diameter and wall thickness decreases the resilience of the line, yet at the same time one has to allow for and permit at all times displacements due to thermal expansion to occur in order to alleviate damaging stresses in the pipeline. The damage could also occur in apparatus coupled to the pipeline.

Hitherto, two methods have been used singly or in combination to try and solve this problem.

1. A suitably resilient construction of the track or line according to the so-called expansion loop principle.
2. The insertion into the track or line of compensators which are considerably more resilient than the basic pipes.

It is a condition of utilisation of the first method that there should be sufficient space to accommodate the displacements or in other words that these displacements should not encounter technological difficulties. One should also mention that when conveying liquid media such as hot water or oil, this construction significantly increases the required pumping capacity.

In the second method several different types of compensator have been used. Amongst these are the so-called lens compensators which are described in detail because they are the most widely used. When larger pressure gradients occur, and when the medium conveyed is chemically aggressive or dangerous primarily this type us used. However, the comments below are also valid for the other types.

The main advantage of lens compensators is that they have a relatively small space requirement, their resilience is

better by an order of magnitude, resulting in a significantly lower reaction force.

For these reasons, the use of lens compensators is now very widespread for power-station pipelines, since in this field one finds simultaneously large dimensions, large temperature differences and large pressures, and also in this context, the availability of space is relatively restricted because of the high construction costs. As has been shown by computer investigations on models in the U.S.A. the use of lens compensators in power stations can result in significant savings by comparison with traditional expansion loop systems, particularly because of lower construction and investment costs. Their other technological advantages justify their installations in other cases also.

Three main types of lens compensators are known: 1. axial; 2. tapped or pinned; and 3. linkage.

These types can be found in the catalogues of the better known manufacturing companies such as Franz Wagner & Company, Industrie Werke of Karlsruhe, and Thermosel. The axial type makes use of the fundamental property of the deformation element of the lens compensator. This is the simplest way of using the principle of operation. Its disadvantage however is that it results in reaction forces which are proportional to the operational pressure and to the square of the diameter of the pipe. For instance, an axial lens compensator installed in a pipeline of 400 mm nominal diameter exerts a reaction force of 10,000 kp at an operational pressure of 6 atmospheres; this also means that at high pressures of say 20—60 atmospheres, which often occur in industrial practice, and which are made possible by the manufacturing technology of lens compensators, the reaction forces are of a magnitude which quite clearly exclude the possibility of the use of axial type in the above-mentioned example of size of nominal diameter. If one uses a larger pipe diameter reaction forces increase very rapidly.

The second type, which is the pin-type of compensator can be characterised by the requirement of a high moment which in turn requires long arm lengths and which makes it problematic to form lines because of a considerable space requirement. The thermal expansion of the pipelines is taken up by an angular displacement. It should be remarked however that this space requirement is significantly less than that for the constructions using expansion loops, i.e. without compensators. The reaction forces are still significant.

The linkage type, also known as the rod type, reliably solves the problem but only within the span of the linkage or rod. The problems of space requirement and reaction forces arise here also. This compensator works in the same way as the pin-type where one is concerned with what happens outside the span of the rod. It is only suitable for lateral, i.e. radial displacement. Neither the pin-type of compensator nor the linkage or rod type make if possible for an axial displacement to take place and they can only be used for pipelines which include bypasses.

Consequently, due to the considerable thermal expansion it is very difficult to connect two different pieces of equipment by means of one single straight pipe section. The large heat expansion and the large reaction forces necessitate the construction of a frame construction for lens compensators of the rod or pin type in order to accommodate these large reaction forces. These frame constructions are, however, axially stiff and thus exclude the possibility of axial displacement.

The present invention seeks to provide a compenstor for thermal expansion which can solve or at least reduce this problem and combine the advantage of the hitherto known constructions without including their disadvantages.

In the expansion compensator according to the invention, the advantages of the frame and of axial displacements are combined by inserting at least one resilient element into the linkage. As regards displacement, this construction corresponding to the serial connection of a traditional linkage type of compensator and an axial type of compensator in which latter, however, only a fraction of the reaction force corresponding to the reaction forces of the system arises, and is equally suitable for lateral and axial displacements. However, technologically, it offers much more than this and generally much more than systems utilising known types of lens compensators, because it combines their function at a higher level.

Its operational principle is simple. Its specific production costs are of the same order as those of the lens compensators which are already being manufactured. In the case of a larger investment unit such as a pipeline system, one can expect significant savings in addition to the technological advantages partly because it is cheaper than the traditional system, in other words it has a higher efficiency and therefore fewer units need to be installed and it can result in savings in the connecting steel pipes and steel constructions and pipe holders.

According therefore to the present invention, therd is provided a thermal expansion compensating device,

comprising an axially expansible and contractible compensator having a pair of spaced apart ends between which an axially extending link is connected, said link consisting of two coaxial parts between which is interposed at least one resilient extensible and contractible element to allow the axial length of the link to vary.

The accompanying schematic drawing describes a preferred embodiment of the invention in elevation.

The illustrated thermal expansion compensator consists of so-called lens waves 1 which are axially expansible and contractible tubular bellows-like elements for accomodating displacements due to thermal expansion, end flanges 2 for ensuring an optimal exertion of forces of the system and rods or links 3, each (or at least one) being provided with a resilient element 4. A respective connecting element 5 connects the links 3 to the flanges 2. The resilient elements 4 may be leaf springs, helical springs or hydraulic spring elements.

The deformation during operation of the compensator lenses requires a force which consists of two main components, one of these being the component characterising the pressure and is due to the force arising from the difference between the inner (internal) and external pressure and secondly, from the force which arises by the work done in the change of shape of the elements 1. This can be expressed as follows:

$$F_{re}=F_p+F_d$$

where F_{re} is the reaction force characterising a predetermined operational state and f_p is a component functionally related to pressure and can be calculated from the internal pressure and the so-called piston diameter, while F_d is the force associated with the deformation of the lens or lenses.

Since in most cases the decisive fraction of the rigidity of the compensation system is given by the element F_p it is expedient to take up F_p with the links 3 and thus to increase the resilience of the system. The demands made on the reslient elements 4 can be satisfied by e.g. springs or hydraulic elements.

The fractions of the total reaction force respectively taken up and transmitted by the links 3 can be adjusted by prestressing the resilient elements 4 or by regulating them in operation.

Thus the force relation of the construction can be expressed:

$$F_{re}=F_p+F_d+F_e$$

where the additional symbol F_e represents the force due to the prestressing of the resilient elements 4.

The above equations are all of course vectorial additions.

By using prestressing or by continuously changing the stressing during the operation, reaction forces of the order of 10—50 Mp may in principle be rendered zero; in practice they can be kept under an upper limit of 1—2 Mp. These constructions provide significant technical and economic advantages for steel constructions.

WHAT WE CLAIM IS:—

1. A thermal expansion compensating device, comprising an axially expansible and contractible compensator having a pair of spaced apart ends between which an axially extending link is connected, said link consisting of two coaxial parts between which is interposed at least one resilient extensible and contractible element to allow the axial length of the link to vary.

2. A device according to claim 1 wherein the or each resilient element is a helical spring.

3. A device according to claim 1 wherein the or each resilient element is a leaf spring.

4. A device according to claim 2 or claim 3, wherein the or each resilient element is prestressed.

5. A device according to claim 1 wherein the or each resilient element is a hydraulic element.

6. A device according to any preceding claim wherein the force exerted by the or each resilient element is continuously variable.

7. A device according to claim 1 substantially as herein described with reference to and as shown in the accompanying drawing.

T. Z. GOLD & COMPANY,
Chartered Patent Agents,
European Patent Attorneys,
9, Staple Inn,
London, WC1V 7QH.
Agents for the Applicants.

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1541294 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale.